

Seed Germination

Definition

- The phenomena of resumption of active growth by the embryo resulting in the rupture of seed coat and emergence of a young plant is known as germination. The results are expressed in terms of percentage (%) by count.
- Germination is the process by which the embryo wakes up from the state of dormancy and takes to active life.

This process, in fact, covers all the changes from the earliest sprouting of the seed till it established itself as an independent plant. A mature seed is living. But the embryo remains dormant.

Types of germination

There are two types of germination are as follows-

1. **Epigeal germination:** During epigeal germination, the cotyledons are raised above the ground where they continue to provide nutritive support to the following points. e.g. Bean, gourd, tamarind, pine etc.
2. **Hypogeal germination:** During germination, the cotyledons or comparable in storage organs remain beneath the soil while the plumule pushes upward and emerges above the ground. Hypogeal germination is characteristic of pea seeds, all grasses and many other species.

Distinguish between epigeal germination and hypogeal germination

| Epigeal germination | Hypogeal germination |
|---|--|
| 1) cotyledons come out above the ground and it does not remain inside the seed coat. | 1) Cotyledons never come out above the ground and it remain inside the seed coat. |
| 2) The plumule comes out of the seed coat by the elongation of the hypocotyl. | 2) The plumule comes out of the seed coat by the elongation of the epicotyl. |
| 3) Hypocotyl elongation is more. | 3) Epicotyl elongation is more. |
| 4) Green in colour and autotrophic. | 4) Not green in colour and heterotrophic. |
| 5) Generally dicot seed shows this type of germination. e.g. Bean, tamarind, gourd etc. | 5) Generally monocot seed shows this type of germination. e.g. Rice, wheat, maize etc. |

Factors/Condition/Requirements of Seed Germination

► External factors

- **Water or Moisture:** The supply of water is very important for germination. The seeds absorb water and swell up. This swelling is the earliest sign of germination. Seed coats are softened and rupture easily to make way for the radicle and plumule to come out. Due to absorption of water, the dormant protoplasm is activated for carrying on the vital functions. It secretes enzymes or digestive juices, which convert the complex insoluble food matters stored up in the seed, either in the cotyledons or the endosperm, into their simpler soluble forms, so that the growing embryo may utilise them. Entrance of oxygen is also facilitated and as a result, the rate of respiration is accelerated.
- **Temperature:** An optimum rate of temperature is essential for germination. Protoplasm cannot carry on vital activities at a very low or at a very high temperature. There is a minimum below which seeds will not germinate and a maximum above which germination will not take place. The suitable temperature, of course, varies with the seeds. Most of the seeds usually show signs of germination when temperature varies from 25°C to 30°C.
- **Oxygen:** Oxygen is essential for aerobic respiration to release energy for the metabolic activities. Therefore, with the exception of the few plants (e.g. rice, Typha etc) seeds usually require oxygen or good aeration for their germination.
- **Light:** Plants differ as to the effect of light on their germination. Seeds of many plants are light indifferent or nonphotoblastic, i.e. they are not influenced in the germination by the presence or absence of light. Most of our important crop plants belong to this category. The seeds which are affected by light are described as photoblastic. Sensitivity to light is a specific character. The photoblastic seeds are of two types, positively photoblastic or light sensitive and negatively photoblastic or light hard. The positively photoblastic seeds require light for germination, e.g. lettuce, tobacco, many grasses and several epiphytes. The negatively photoblastic seeds cannot germinate in the presence of light e.g. Tomato, Onion, Lily etc.
- **Other factors:** Many orchids and other plants exhibit seed germination only when an appropriate fungus partner is available. Seeds of some parasitic plants will similarly grow only in the vicinity of their host roots because the latter excrete certain growth hormones. Seeds of some aquatic plants germinate only at low or acidic pH.

► Internal Factors

- **Vitality:** The ability of a seed to germinate when provided with optimum condition is described as vitality of the seeds. It is dependent upon its stored food, size, health etc.
- **Longevity or viability:** With the passage of time, a seed loses its power to germinate. Thus each seed has longevity or a period within which it can show renewal of growth or germination. Most of the crop plants lose their viability within 2-5 years. Legumes ordinarily retain their viability for longer periods. A number of seeds have been recorded to remain viable even after 100 years (e.g. *Trifolium*, *Astragalus*, *Mimosa* species). Many species remain viable only for one season, e.g. Birch, Elm, Tea.
- **Dormancy:** Seeds of many plants are dormant at the time of shedding. Seed dormancy may be due to various reasons like impermeability, toughness of seed coats, presence of growth inhibitors etc. Such seeds germinate only after natural breakage of dormancy.
- **Foods and growth regulators:** Food is necessary for growing embryo. This comes from cotyledons or endosperm. Some growth regulators are required for growth during germination. During germination a chemical called auxin develops in the seed which stimulates germination. In addition to this, another substance known as Hetero auxin develops in some seeds. Both auxin and hetero-auxin are termed as growth regulators.
- **Completion of rest period:** Many seeds do not germinate immediately after harvest but undergo a period of rest which varies from plant to plant.

Process/pattern of Germination

Germination process involves a complex sequence of metabolic activities. The complex sequence of this process may be divided into following stages-

1. Imbibition of water.
2. Enzyme activation and digestion.
3. Initiation of embryo growth.
4. Rupture of seed coat and emergence of Seedling.
5. Establishment of seedling.

1. **Imbibition or uptake of water:** The first step in germination is imbibition or uptake of water by the dehydrated seed. The seeds, when placed in moist soil, absorb water through micropyle. Imbibition causes the seed to swell as the cellular constituents are dehydrated. Imbibition takes place with great force. It ruptures the seed coat and enables the radicle to emerge. It causes swelling of seeds and development of the great force called imbibition pressure.

2. **Enzyme activation and digestion:** This stage is characterized by the initiation of cellular activity with the appearance of specific enzymes and increase in respiratory rate. The appearance of enzymes triggers the chemical reactions. Digestion, translocation and assimilation of stored food materials in the seed take place.
3. **Initiation of embryo growth:** An increase in the size of root-shoot axis (epicotyl, hypocotyls, radicle) occurs following enzymatic activation and other phenomena in the sequence. The growth of the root-shoot axis occurs at the expense of the storage tissues, which gradually decrease as food reserves are depleted. By the time, the young seedling is able to synthesize its own food, most of storage tissues have been exhausted.
4. **Rupture of seed coat and emergence of seedling:** During the imbibition stage, swelling of the seed may rupture the seed coat. However, the rupture is usually caused by internal pressure from the enlarging root-shoot axis. In dicotyledonous, pressure may also develop between the cotyledons, forcing them apart and rupturing the seed coat permitting emergence of growing points.
5. **Seedling growth and establishment:** The seedling grows by the usual process of cell division, enlargement and differentiation at the growth points. The initial growth of seedling follows two patterns; epigeous and hypogeous. In epigeal germination, the hypocotyl elongates and raises the cotyledons above the ground. While in other case, the lengthening of the hypocotyl does not push the cotyledons above the ground but only the epicotyl emerges.

The seedling starts to establish itself with the beginning of water uptake and photosynthesis. The seedling becomes firmly established when it manufactures most of its own food. Then the germination process is complete.

Promotion of seed Germination

► Chemical stimulation

Potassium nitrate (KNO_3): Widely used chemical germination, at conc. 0.1-1.0% KNO_3 is substitute of light. May be detrimental to some seeds. e.g. lettuce failed to germinate with KNO_3 under dark condition.

Nitrate (NO_3^-): NO_3^- can act as a source of N and a seed germination enhancer.

Hydrogen peroxide (H_2O_2): This chemical act as respiration stimulant. e.g. Tomato.

Thio-urea: Promotes germination in many seeds.

- Substitute for light and temperature requirement for Physiological process occurring during after ripening.
- Replace the growth promotion develops naturally during stratification.

Gibberellin: Gibberellin have been known to promote seed germination. Gibberellins enhance seed germination by inhibiting ABA activity.

- Gibberellins are necessary for the production of mannanase, which is necessary for seed germination.
- Gibberellin can substitute for light and temperature requirement is promoting germination.
- They can also promote germination of seeds not having these requirements.
- GA like substances have also been isolated from seeds of bean, lettuce and many other species.

Auxin: IAA is also able to affect seed germination by affecting the activity of enzymes; for example, in germinating pea seeds, the activity of glyoxalase was regulated by IAA, resulting in higher rates of cell growth and development. IAA has been shown to increase lettuce seed germination at conc. 10^{-1} M and to be temperature dependent. Auxin can influence seed germination, when ABA¹ is present.

Cytokinins: Cytokinins are plant hormones, regulating a range of plant activities including seed germination. They are active in all stages of germination. Cytokinins are also able to enhance seed germination by the alleviation of stresses such as salinity, drought, heavy metals and oxidative stress.

¹ ABA= Absciscic Acid

Brassinosteroids (BR): Brassinosteroids (BR) are a class of plant hormones, similar to the steroid hormones in other organisms. BR is able to enhance seed germination by controlling the inhibitory effects of ABA on seed germination.

Ethylene (C₂H₄): Ethylene is known to stimulate seed germination of many species. It has been shown to enhance germination rate of aged as well as immature seed.

The amount of ethylene increases during the germination of many plant seeds including wheat, corn, soybean and rice, affecting the rate of seed germination. Ethylene is thought to be involved in regulating auxin levels in dormant seed.

► **Germination promotion by other method**

- **Pre-sowing hardening or pre-soaking treatment:** Pre-soaking seeds in water has been suggested as a means to speed up germination.
- Completes different stages of germination including hydrolytic process.
- Wetting and drying cycles act on the seed coat.
- Enables seed to germinate under adverse condition.